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NEW JERSEY



AGRICULTURAL EXPERIMENT STATIONS

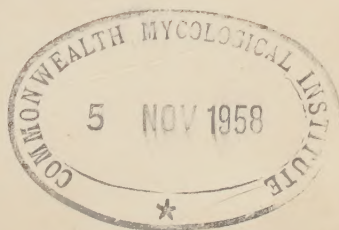
CIRCULAR 97



Fig. 1. Crown gall on rose bush.

COMMON DISEASES OF ORNAMENTAL PLANTS

NEW BRUNSWICK, N. J.



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COMMON DISEASES OF ORNAMENTAL PLANTS¹

The increasing number of inquiries concerning diseases of ornamental plants has led to the preparation of this brief discussion of the more common diseases and their treatments. These discussions are necessarily brief because the diseases of this class of plants have been studied less than the diseases of any other group of cultivated plants, but they are deserving of much more attention than they have received. The growers of ornamental plants for market purposes frequently suffer heavy losses which could be avoided by the proper treatment. The ornamental plantings about homes enhance the value of the property and are the subject of much attention, care and frequently expense on the part of the owners.

In this circular we have made no effort to discuss all the diseases of ornamental plants, but only the most common ones, and in most cases those concerning which we have had inquiries.

Diseases of ornamental plants may be due to fungi or bacteria attacking various parts of the plant, or they may be due to improper conditions of soil, heat, moisture and light, or to unknown causes. The treatment must vary with the cause, character and location of the disease. In some cases the plants can be sprayed, in other cases the soil can be treated, in the greenhouse the light, heat and moisture can be modified, but in many cases it is best to destroy the sick plants. In all cases it is better to prevent the disease, if possible, rather than to treat diseased plants.

The diseases may be classified for convenience as (1) those that attack the roots, causing dwarfing, wilting or death of the plants; (2) those that attack the stems, causing cankers and abnormal growths; (3) those that attack the leaves, causing spots, mildews and blights; (4) those that attack the flowers and cause decays, dwarfings and abnormalities of many kinds.

¹ Prepared March 1, 1918, by Mel. T. Cook, Ph.D., Plant Pathologist of the New Jersey Agricultural Experiment Station.

The most common of these diseases will be discussed and remedies suggested where possible. The troubles caused by insects belong to a different department and, therefore, will not be discussed in this circular.

FLOWERING ALMOND, PEACH AND CHERRY

CROWN GALL (*Bacterium tumefaciens* S. & T.). These plants belong to the family *Rosaceæ* and are subject to severe attacks of the crown gall, which will be described in connection with the diseases of roses (p. 15). The flowering scions are frequently budded or grafted into other rosaceous stock and the wound makes most excellent conditions for infection. This may or may not prove of much importance, but it is advisable to avoid the use of seriously infected plants.

NOTE: Galls may be due to other causes. Nematodes are small microscopic worms which infest many greenhouses and are the most important cause of galls on many plants.

AMPELOPSIS (IVY)

LEAF SPOT [*Phyllosticta ampelopsidis* (E. & M.)]. This disease is very abundant, especially on the lower leaves of the old plants and on nursery stock. It is seldom found more than six or eight feet above the ground. It can be controlled on nursery stock by spraying with Bordeaux mixture, but this treatment is impracticable with vines growing on buildings or high walls.

DIE BACK (*Cladosporium* sp.). The organism causing this disease is very generally found on the old fruits, but under favorable conditions it frequently attacks the vines and causes the death of large branches. It is most destructive on weak plants during dry weather. When very severe, long branches of the plant and sometimes the entire plant wilt and die. Our experimental work with this disease indicates that its severity depends on lack of water and plant-food. The location of most of these plants on walls is such that they secure the benefits of rain-fall from one direction only and this is sometimes greatly reduced by the water spoutings of the building. Furthermore, the soil around old plants is very likely to be greatly impoverished. Heavy applications of stable manure or commercial fertilizers spaded into the soil and heavy applications of water during dry seasons will usually give the desired results.

ASTERS

YELLOWS (cause unknown). This is the subject of a great many inquiries. The diseased plants produce weak yellowish shoots and sometimes the entire plant is deformed. The flowers on the diseased shoots are also deformed and of no value. It is prevalent in the field but very seldom found on plants growing under glass. It is believed by some workers to be associated with insect (aphis, tarnish bug, etc.) injuries, but this has not been demonstrated. There is no known remedy.

WILT OR STEM ROT (*Fusarium* sp.). This is a disease of the China asters. The lower leaves wilt and become yellow, followed by the death of the plant and a rotting near the surface of the ground. This organism probably lives over in the soil and therefore the plant should not be grown year after year in the same soil.

Root Rot (*Rhizoctonia*). See Carnation Rot (below).

CALLA

SOFT ROT (*Bacillus aroides* Townsend). This is a bacterial disease which attacks the rhizomes at about the time of flowering. It originates near the surface of the soil and progresses both up and down. The leaves lose their green color and fall. The infected parts are brown, soft and watery. The disease may work either slowly or rapidly. There is no known remedy, but it is advisable to practice crop rotation and to avoid setting bulbs, rhizomes or fleshy root plants in infected soil.

CARNATIONS

ROOT AND STEM ROT (*Rhizoctonia*). This is one of the most important of the fungous diseases of carnations. The diseased plants wilt and die. The roots and base of the stem show a pronounced rot. This disease is very common and widely distributed. It attacks such a large number of plants that it is sometimes difficult to control. In fact, there are no very satisfactory methods of control other than the practice of good cultural methods. Good drainage, loose thoroughly aerated soil and crop rotation are advantageous. In digging and handling the plants, care should be taken to prevent breaks and bruises which form points of infection. Avoid the excessive use of compost.

WILT, STEM ROT OR DIE BACK (*Fusarium* sp.). This disease also is due to a soil fungus, but in this case the fungus

works entirely within the tissues of the plant. The leaves turn yellow and dry. The branches and sometimes the main shoot dies. The only satisfactory treatments for this disease are crop rotation and soil sterilization.

RUST [*Uromyces caryophyllinus* (Schrank) Wint.]. This is one of the most common, and for a long time was considered one of the most important, diseases of the carnation. It is readily recognized by the circular or elongated blisters on the leaves and stem which break through the skin of the plant and give rise to the yellowish or brownish powder. This powder is composed of the spores of the fungus by which the disease is spread from plant to plant. It can be held in check by the selection of cuttings from healthy plants, sub-irrigation and good ventilation. The application of water to the tops of the plants tends to spread the disease very rapidly. Some varieties are said to be more resistant to the disease than others. Among the most important of these are Enchantress, Mrs. C. W. Ward, White Perfection, Beacon, Matchless, White Wonder, Pink Delight and Benorah.



Fig. 2. Bud rot of carnation.

ANTHRACNOSE (*Volutella dianthi* Atk.). This is a fungous disease which attacks the parts of the plants in contact with wet soil, and is sometimes of considerable importance, especially on cuttings.

STEM AND LEAF SPOTS. There are a number of stem and leaf spot diseases, but as a rule they are of comparatively little importance.

BUD ROT (*Sporotrichum poæ* Peck) (Fig. 2). This is not a very common disease, but is sometimes of considerable importance. It is a fungous disease which is well described by its name. The buds rot when just about ready to open. As a result many buds never open, and others produce imperfect flowers which are infected with the rot. The fungus is carried from bud to bud by a very small insect known as a mite. Therefore, fumigation which destroys these mites will stop the spread of the disease which can be eradicated by destroying the diseased plants.

STIGMONOSE is a general term applied to plant injuries caused by such insects as aphids, thrips and leaf hoppers. In the case of carnations it appears as small translucent, swollen spots, or small translucent slightly sunken spots or spots with a purplish margin. The control consists of fumigation for the destruction of the insects.

YELLOWs (*cause unknown*). This disease appears as irregular sunken spots of various sizes, but usually yellowish or pinkish in color, or yellowish or pinkish streaks; in severe cases the plant may be dwarfed, the leaves and sometimes the entire plant dying. There is no very satisfactory remedy, but the diseased plants should be removed. Some varieties, especially the red-colored ones, are said to be more susceptible than others. Princess Dagmar is very susceptible and Beacon, Mrs. C. W. Ward, Enchantress and others are sometimes affected.

CHRYSANTHEMUMS

RUST (*Puccinia chrysanthemi* Roze). This is one of the most common of the fungous diseases. It occurs on the leaves as small brown blisters which increase in size and sometimes form concentric circles. The skin of the plant is finally ruptured and a fine brownish powder escapes. This powder is composed of the spores of the fungus by which the disease spreads from plant to plant. It is most abundant on the lower leaves of the plant and in severe cases the leaves shrivel and die, the plants are dwarfed and fail to produce flowers. Badly infested plants should be picked and burned. Spraying with potassium sulfide (liver of sulfur) is advantageous in holding the disease in check.

POWDERY MILDEW (*Oidium chrysanthemi* Rbh.). This fungous disease occurs on the foliage as a white powdery covering. In most cases it is not serious. It can be controlled by spraying with potassium sulfide [liver of sulfur (p. 22)].

WILT (*Fusarium* sp.). This is a fungous disease which attacks certain varieties, causing them to wilt and die slowly. The fungus lives within the plants and clogs up the water passages. The diseased plants should be destroyed. The infected soil should be sterilized or planted with some other crop not subject to the disease.

LEAF SPOTS (*Septoria chrysanthemi* Allesch., *Cylindrosporium chrysanthemi* E. & D., *Phyllostictia*) are quite common and can be controlled by spraying with Bordeaux mixture.

DAISY

CROWN GALL.—The Paris daisy (*Chrysanthemum frutescens*) and related plants are subject to crown gall, which produces large knots or cancer-like growths on the main shoot and branches. (See crown gall, p. 15.)

EUONYMOUS

CROWN GALL. Several cases of this disease on the roots and lower parts of the stems of *Euonymus* have been reported to the department of plant pathology of the New Jersey Agricultural Experiment Station. It does not appear to be very serious. (See p. 15.)

GLADIOLUS

BULB ROT (*Septoria gladioli*). This is a fungous disease which causes a hard rot of the bulbs or corms. On removing the outer husks from diseased bulbs, very small water-soaked reddish brown to blackish spots will be found, usually on the upper half. These spots increase in size, become black and sunken and dry. The disease also attacks the leaves, causing very small circular brown or purplish areas. These spots increase in size and in advanced stages the centers become grayish and sometimes drop out, thus producing the shot-hole effect. The most satisfactory treatment consists of selecting healthy bulbs or corms, which should be set in clean soil. In the selection of these corms it is necessary to remove the husks and examine each corm carefully.

ROOT ROT (*Rhizoctonia* sp.). This is a fungous disease which causes a rotting of the roots and a corresponding dwarfing of the parts above ground. This fungus lives over in the soil, and therefore these plants should not be reset year after year in the same soil.

HOLLYHOCK

RUST [*Puccinia malvacearum* (Mont.)] (Fig. 3). This is the most common fungous disease of the hollyhock. It causes brownish, elevated wart-like spots which may be circular or elongated, depending on their location on the leaves or stems. As they approach maturity the epidermis or skin breaks and a brownish powder escapes. This powder consists of the spores of the fungus, by which the disease is spread from plant to plant. In severe cases, the leaves wither and die, the plants are dwarfed and they do not produce blossoms of the normal number and size.



Fig. 3. Hollyhock rust. (R. F. P.)

The disease can be held in check by spraying with Bordeaux mixture (p. 22, 23) or by spraying the diseased parts with permanganate of potash. However, these treatments are rather displeasing to the eye, and therefore it is important to grow plants that are free from the disease. When the disease is severe it may be advisable to destroy the old plants and start with new stock. The old plants and all the litter about the plants should be burned early in the fall. Watch the young plants carefully in the spring and pick off and burn all diseased leaves as soon as they appear.

LEAF SPOT [*Cercospora altheina* Sacc., *Phyllosticta altheaina* Sacc., and *Colletotrichum malvarum* (B. & C.) South]. These

diseases are more or less common and sometimes very injurious. They can be controlled by spraying with Bordeaux mixture.

IVY

(See Amelopsis, p. 4.)

LILAC

POWDERY MILDEW [*Microsphaera alni* (Wallr.) Wint.]. This is an extremely common fungous disease which attacks the foliage of the lilac and many other plants. It appears about midsummer as a grayish or whitish covering over the surface of the leaves. It can be controlled by spraying with potassium sulfide (liver of sulfur, p. 22), but is of so little importance that usually no effort is made to control it.

LEAF SPOT. This is a bacterial disease which appears as rather large, irregular water-soaked areas. The only satisfactory control consists in the cutting out and burning of the diseased parts.



Fig. 4. Sclerotinial wilt of Lily-of-the-Valley. (R. F. P.)

LILY-OF-THE-VALLEY

SCLEROTINIAL WILT (*Sclerotinia* sp.) (Fig. 4). This is a fungous disease which sometimes causes the wilting and dying

of the plants over a considerable area. The sclerotial bodies of the fungus are frequently found within or on the surface of the dead plants, especially if they have been covered with dead leaves. The diseased plants should be pulled out and burned, and in case of severe outbreaks it may be necessary to destroy the entire planting and start with healthy plants on clean soil. This or a similar disease attacks many other plants.

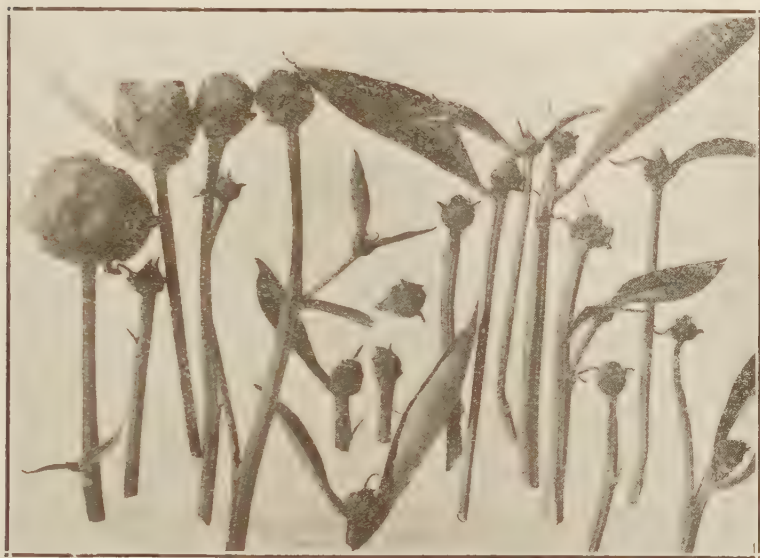


Fig. 5. Bud rot of peony. (R. F. P.)

PEONY

BUD ROT (*Botrytis* sp.) (Fig. 5). This disease attacks the buds before they reach maturity, causing them to die and blacken. It also attacks the leaves and stems, causing large irregular black spots. It is very difficult to control. The old plants should be cut very close to the ground in the fall in order to remove all diseased parts, which should be burned. Spraying with Bordeaux mixture is effective, but undesirable because of its tendency to discolor the foliage. Dusting flowers of sulfur on the plants is said to be very effective. It is advisable to collect and burn the old plants and all rubbish in the fall. (See Sanitation, p. 20.)

This or a similar disease attacks chrysanthemums, poinsettia and other plants.

STEM ROT (*Sclerotinia* sp.). This disease causes the stems to wilt and rot off near the ground. The stems frequently split and the large black sclerotial bodies are found in the pith. Cutting of the diseased stalks near the ground, and burning them, is the only known satisfactory remedy.

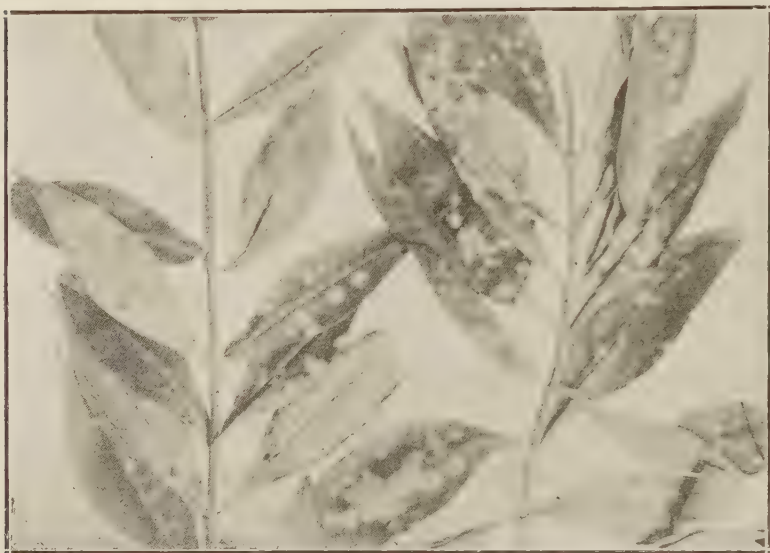


Fig. 6. Mildew on phlox. (R. F. P.)

PHLOX

POWDERY MILDEW (*Erysiphe cichoracearum* D. C.) (Fig. 6). This fungous disease is very common in New Jersey, and is the subject of many inquiries to the department of plant pathology of the New Jersey Agricultural Experiment Station. It starts as a white powdery growth on the lower leaves and gradually becomes dark, sometimes very black. The leaves gradually die, the flowers are dwarfed and the beauty of the plants greatly reduced. It can be controlled by spraying with potassium sulfide (liver of sulfur, p. 22).

PRIMROSE

STEM ROT (*Botrytis* sp.). This is a fungous disease of the stem very similar to the stem rot of the peony (above), but is most prevalent on plants grown under glass. It can be controlled in the same manner as the peony disease and by reducing the water supply.

PRIVET

ANTHRACNOSE (*Glauosporium cingulatum* Atk.). This is a fungous disease which causes canker-like spots on the twigs. These spots frequently girdle the twigs and cause the death of all parts beyond the point of injury. It is sometimes very destructive, especially in the cutting bed. Badly-diseased plants should be cut and burned. Spraying with Bordeaux mixture in the spring before the buds open is very beneficial.



Fig. 7. Rose mildew. (R. F. P.)

ROSE

POWDERY MILDEW [*Sphaerotheca pannosa* (Wall.) Lev., var. *rosa* Wor.] (Fig. 7). This is a very common fungous disease, which is the cause of many inquiries to the New Jersey Agricultural Experiment Station. It occurs as a powdery growth on the leaves, and when severe causes a pronounced curling and frequently a dwarfing of the shoots and flowers. It is especially severe on Crimson Rambler out-of-doors (fig. 8), and is also a very troublesome pest on roses grown under glass. The satisfactory treatments for out-of-door plants is spraying with potassium sulfide (liver of sulfur, p. 22) or dusting with sulfur and arsenate of lead (p. 22).

The most satisfactory treatment for roses under glass is flowers of sulfur applied either as a dust to the plants while wet, or made into a paste and placed on the steam pipes.



Fig. 8. The effect of mildew on the crimson rambler.

BLACK SPOT [*Diplocarpon rosæ* (Lib.) Wolf]. This is a very common and very troublesome fungous disease on the foliage of some varieties of roses grown under glass. It also occurs

on some varieties of out-door roses. It produces more or less circular black spots with extremely irregular borders. These spots tend to turn gray with age in the center, and the leaf tissues die at this point. The diseased leaves have a tendency to turn yellow and fall. If possible, they should be gathered and burned. The disease can be held in check by spraying with Bordeaux mixture or dusting with sulfur and arsenate of lead (p. 22). Bordeaux mixture tends to discolor and to burn the foliage. Good greenhouse management will help to hold the disease in check.

ANTHRACNOSE (*Glaesporium rosa* Halst.). This is a fungous disease which is sometimes confused with black spot. The spots are much more regular in outline than the black spot and are also very abundant on stems. Where severe the disease defoliates the plants. The diseased parts should be cut out and burned. The further treatment is the same as for black spot.

RUST [*Phragmidium subcorticium* (Schrank) Wint., and *P. speciosum* Fr.]. These two rust diseases are sometimes of considerable importance. The diseased plants should be cut and burned.

OTHER LEAF SPOTS. There are some other leaf-spot diseases of minor importance, which will usually be controlled by the regular spray treatments.

CANE BLIGHT (*Coniothyrium fuckelii* Sacc.). This fungous disease has been sent to the plant pathology laboratory of the New Jersey Agricultural Experiment Station several times. The diseased plants wilt and die rather slowly. An examination of the canes shows many discolored spots which are followed by a splitting of the bark revealing the presence of the black fruiting bodies of the fungus. This disease also attacks the raspberries. The most satisfactory treatment consists in the destruction of the diseased plants. However, in the case of slight infections, the pruning out of diseased parts may prove successful.

CROWN GALL (*Bacterium tumefaciens* S. & T.). This is a bacterial disease which causes large tumor-like knots or galls on the roots and stems. When severe it dwarfs the plants and sometimes causes death.

This disease also attacks a very large number of other plants, of which the following is a partial list: Almond, apple, arbutus, alfalfa, blackberry, beet, cherry, chestnut, clover, corn, cotton, dewberry, Euonymus, daisy, grape, hop, honeysuckle, marigold, oleander, peach, pear, plum, prune, poplar, raspberry, willow, etc.

The only satisfactory control consists in the destruction of the diseased plants. It is advisable to put in new soil or to sterilize the old before setting plants susceptible to this disease.

SNAPDRAGON

RUST (*Puccinia anthirrini*). This is a common fungous disease which causes brownish blisters on the leaves and stem. These blisters break and the brownish spores escape. The disease can be controlled by using cuttings from strictly healthy plants, by removing seriously infected plants, by sub-irrigation and by spraying with potassium sulfide (liver of sulfur, p. 22), or by dusting with sulfur and arsenate of lead (p. 22). This treatment should not be used after the plants begin to bloom.

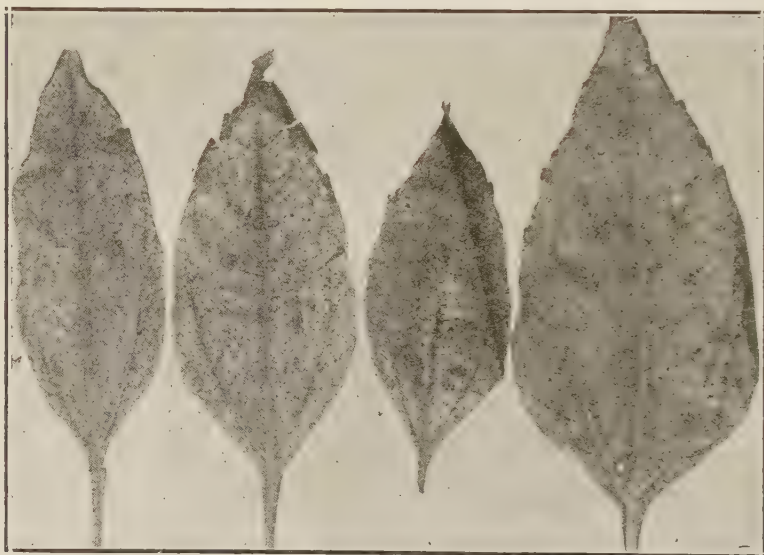


Fig. 9. Sunflower rust. (R. F. P.)

ANTHRACNOSE (*Colletotrichum anthirrhini*). This is a fungous disease, which causes small, irregular, sunken spots on the stems and leaves and retards the growth of the entire plant. The disease can be controlled by using cuttings from strictly healthy plants and by spraying with Bordeaux mixture every two weeks until the plants approach maturity.

SUNFLOWER

RUST (*Puccinia helianthi* Schw.). (Fig. 9). This is a very common fungous disease of the foliage which can be recognized

by yellowish or brownish spots which become black with age. When severe, the leaves become yellow, shrivel, die and fall. Burning the diseased plants is the most satisfactory remedy.

SWEET PEA

ANTHRACNOSE [*Glomerella rufomaculans* (Berk.) V. Sch. & Sp.]. This is a very common fungous disease, which causes a wilting and dying of the tips of the shoots and tendrils and whitish spots on the leaves. It also attacks the pods, which become pale and shriveled. The disease is transmitted from plant to plant and is carried from year to year by seed from these diseased pods. The diseased seeds are likely to be small and somewhat shriveled as compared with seeds from healthy plants. This organism also attacks a number of other plants, including the apple, on which it produces a bitter rot disease. It can be controlled by a 3-4-50 Bordeaux mixture.

POWDERY MILDEW [*M. alni* (Wall.) Wint.]. This is the same as the mildew of the lilac (p. 10). It attacks plants both out-of-doors and under glass. In the case of out-door plantings, use the potassium sulfide treatment (p. 22) and in case of indoor plantings use the sulfur treatment (p. 22).

STREAK (*Bacillus lathyri* M. & T.). This is a bacterial disease which causes light reddish brown to dark brown spots and streaks on the stems at blooming time. It also attacks the leaves, causing small circular spots which frequently coalesce and sometimes involve and kill the entire leaf, and also the flowers, causing symptoms similar to those on the stems. The disease spreads rapidly and the plants die early. It can be transmitted from plant to plant and from year to year by the seed. The most satisfactory control lies in the selection of seed from healthy plants.

MOSAIC (cause unknown). This is similar to the mosaic disease of many other plants. It causes a mottling of the foliage which, in some cases, is very beautiful. In severe cases it causes a dwarfing of the plants or a curling and dropping of the foliage. There is no satisfactory treatment.

ROOT ROTS. These diseases are very common and may be due to any one of a number of causes, the most prevalent one being known as **THIELAVIA ROOT ROT** (*Thielavia basicola* Zopf). The roots rot and sometimes the disease works up the stem for a distance of two or three inches above ground. The diseased plants are dwarfed and not as productive as healthy

ones. Other root rots are due to *Rhizoctonia* (p. 5), *Chaetomium spirachta* Pott., and to *Fusarium lathri* Taub. The most satisfactory treatment for these diseases is soil sterilization.

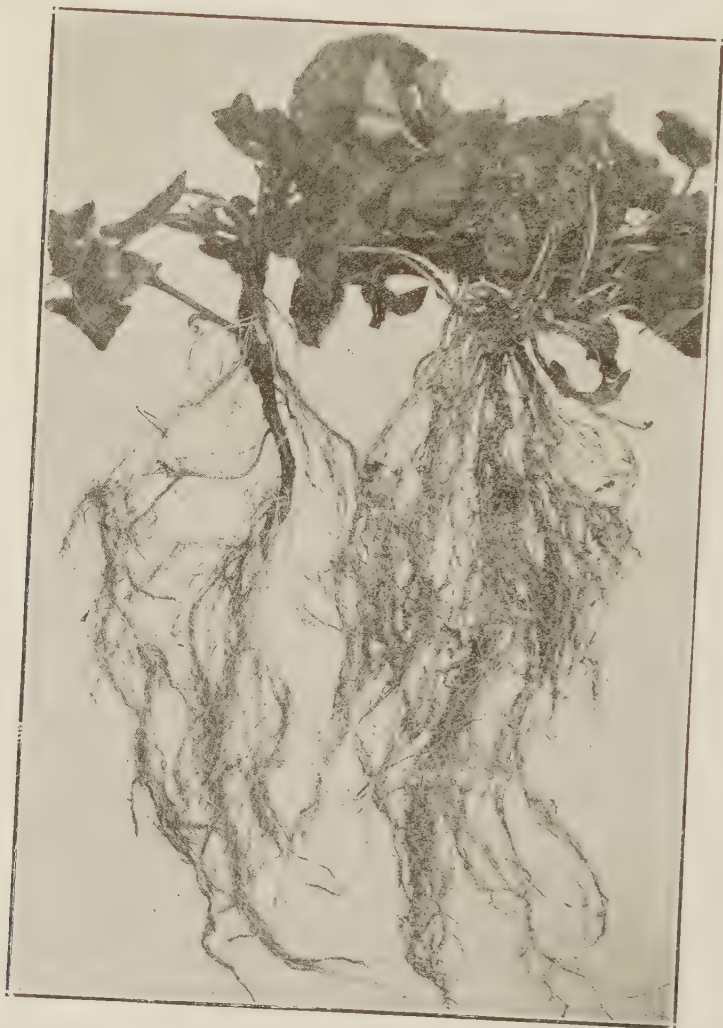


Fig. 10 Root rot of violet.

COLLAR ROT (*Sclerotinia libertiana*). This is a fungous disease which is most destructive as a damping-off fungus on seedling plants.

VIOLET

ROOT ROT [*Thielavia basicola* (B. & R.) Zopf] (Fig. 10). This is one of the most destructive fungous diseases of the violet. It is the same as the root rot of the sweet pea (p. 17). The roots rot, beginning with the tips, the upper part of the older roots send out new rootlets, which in turn also rot. Therefore, diseased plants frequently show a great mass of fine rootlets. The only satisfactory treatment is soil sterilization (p. 20), and the use of cuttings from healthy plants.

FOLIAGE DISEASES. Violets are subject also to several leaf-spot diseases, including a mildew and a rust, which under certain conditions become of considerable importance. The best control for these diseases consists in the practice of good cultural methods, such as selection of good stock, good ventilation, burning of old plants and rubbish and the avoiding of overcrowding. When the diseases are severe it may be necessary to spray the plants.

GENERAL TREATMENTS

GREENHOUSE MANAGEMENT. In the growing of ornamentals in the greenhouse the problem of controlling plant diseases is very closely associated with the art of greenhouse management. It is well known that character of soil, temperature, humidity, sunlight and many factors are important in successful greenhouse work. These factors influence the diseases as well as the plants. This subject is so extensive that we cannot give more than a very brief discussion at this time.

MIXED CROPS. The failure in many greenhouses can very frequently be traced directly to the growing of different kinds of plants in the same house. If these plants require different degrees of temperature, humidity and sunlight, and since the house cannot be regulated to suit all of them at the same time, some must necessarily be failures.

CROP ROTATION. The organisms which cause many of our plant diseases are carried from year to year in the soil. However, many of these diseases are restricted to certain plants, some of them attacking only one variety and some attacking two or more varieties. Therefore, it is advisable to practice rotation of crops as far as possible.

Although this applies more strictly to field and garden crops, it can be practiced to an advantage with many ornamentals, especially those that are grown for commercial purposes.

SANITATION. It is well known that many diseases are carried over on the roots, leaves and stems of the plants of the previous year. When a disease has been severe on any crop, it is advisable to rake and burn the dead plants and rubbish. However, it is impossible to destroy all the fragments of the old plants, and therefore crop rotation also should be practiced. Many successful greenhouse men pick off and destroy diseased parts of plants and frequently entire plants as soon as a symptom of disease appears.

MANURES AND FERTILIZERS. Manures are the most desirable fertilizer for most crops, but are sometimes the source of very destructive diseases. Many growers throw diseased and decaying materials on manure heaps, from which the organisms of disease are returned to the soil. Litter which has been used for bedding for livestock is frequently thrown on the manure heap and then carried to the soil, thus carrying its disease back to the land.

SEED-BEDS AND SOIL STERILIZATION. Seed-beds and cold-frames should be prepared with the greatest care in order to prevent infection of young plants before setting. In most cases manures are used in seed-beds and cold-frames, but the fact that certain diseases are carried in this way and that damping-off organisms thrive in the manure makes it desirable to use nothing but commercial fertilizers in some cases. (Of course when commercial fertilizers are used it may be necessary to use artificial heat.) It is advisable to put the seed-beds or cold-frames in a new place each year if possible, but if this is not done the old soil should be removed or both soil and woodwork sterilized. If the soil is removed care should be taken that it is all taken out, and carried a considerable distance away. A small amount of soil left in the beds is frequently sufficient to perpetuate the disease. If the soil is not carried away from the bed small particles are likely to be returned to the bed on implements or on the feet or hands of the workers. The woodwork of the seed-beds should be thoroughly drenched with either hot water, a solution of formaldehyde (1 pound of formaldehyde in 20 gallons of water), Bordeaux mixture, or strong lime-sulfur mixed with whitewash. If the old soil is used, or if there is any reason to suspect that new soil is infected, it should be sterilized with steam or formaldehyde.

SOIL STERILIZATION is usually used in seed-beds, cold-frames and greenhouses, but is sometimes used on soil in the open. The most common methods are the use of formaldehyde and of steam.

The soil to be treated should be loose and moist. Formaldehyde solution (4 pounds of formaldehyde to 50 gallons of water) should be applied at the rate of 1 gallon to each square foot of soil surface. In case the soil is very loose it may be necessary to make the application slowly over several hours, otherwise the liquid will run through very quickly and be lost. The soil should not be stirred during treatment. Immediately after treatment the soil should be covered with burlap, old carpet, fertilizer bags or paper for two days. It should then be aired for ten days or two weeks, and during this time should be stirred thoroughly three or four times. If this is not done the seed may not germinate well.

The most common method for steam sterilization is known as the inverted-pan method. The pans can be made of No. 22 galvanized sheet iron or pine tar lumber. For out-of-door work they should be made about 6 x 10 feet. They are attached to a boiler of 15 horse-power or more by means of a common 1-inch garden hose which connects with a nipple in the center of the pan. The edges of the pan should be pushed down into the loose soil and weighted. The steam should then be turned on and the temperature held at 200° to 250° F. for about one hour in order to get the best results.

This treatment cannot be used satisfactorily on shale soils or any other soil that tends to pack. Sometimes the first crop on soil subjected to high steam sterilization does not thrive, but the second crop is usually satisfactory.

Caution. Do not add manure or untreated soil to the seed-bed after sterilization; it may carry organisms of disease and cause infection. The diseases that persist in the soil can be very readily carried on the farm implements and also on the feet of the workmen and work animals. Therefore, it is usually necessary to take precaution to prevent infection of clean soil in this way.

Some diseases are carried on the work tools during the growing season. If these diseases are present, the crop should not be cultivated or harvested when wet from dew or rain, and the tools should be thoroughly cleansed or disinfected before using them on another crop which is susceptible to the same diseases.

SEED SELECTION. Some diseases can be avoided or held in check by seed selection. The seed should be selected from healthy plants that yield a product of the size and quality desired.

CUTTINGS. In making cuttings great care should be exercised in the selection of nothing but healthy plants. These cuttings

should always be set in sand or soil free from disease organisms, preferably sterilized soil.

RESISTANT VARIETIES. The control of some diseases is so difficult and expensive and the results so uncertain that it is advisable to grow varieties resistant to the diseases in question. The susceptibility of some of our old varieties to disease accounts for their disappearance from the market.

INSECT CARRIERS. The organisms of some diseases are carried by insects, and therefore it is very important to eradicate insects as far as possible.

SPRAYING. Our knowledge of spraying ornamental plants is rather limited. Some spray mixtures injure the plants and do more harm than good. The fact that a certain mixture can be used on special species or varieties without injury is not evidence that it can be used on others. It is always advisable to test the spray mixture on a few plants before using it on any considerable number of plants.

AMMONIACAL SOLUTION OF COPPER CARBONATE. This mixture will not stain the foliage and therefore is frequently used as a substitute for Bordeaux mixture on ornamentals and on fruits just before ripening. However, it is a treacherous mixture and should never be used without first testing on a few plants. It is made as follows:

Copper carbonate,	6 ounces.
Ammonia (26° Baumé),	3 pints.
Water,	50 gallons.

Dilute the ammonia with 15 pints of water. Mix the copper carbonate in a small amount of water to form a paste. Mix the paste in the dilute ammonia. Add enough water to make 50 gallons. Use immediately. It deteriorates very rapidly.

POTASSIUM SULFIDE (liver of sulfur). Mix 1 ounce of potassium sulfide in a small amount of water to form a paste. Then mix in 2 or 3 or 4 gallons of water and use immediately. This is the most satisfactory treatment for powdery mildew.

FLOWERS OF SULFUR. This is used extensively for mildews in greenhouses. It can be applied as a dust to the plants when wet, or mixed into a paste and smeared on the steam pipes.

DUSTING WITH SULFUR AND ARSENATE OF LEAD has proved to be an exceptionally good treatment for a number of diseases, as previously referred to in this circular. The sulfur should be ground very fine and mixed with arsenate of lead at the rate of

90 parts of sulfur to 10 parts arsenate of lead by weight. This mixture should be fine enough to pass through a 200-mesh sieve and may be obtained ready-mixed from a number of manufacturers.

For information concerning the making and use of lime-sulfur see Circular 24, and for information concerning the making and use of Bordeaux mixture see Circular 48, of the New Jersey Agricultural Experiment Station. The lime-sulfur is very seldom used on ornamentals. The Bordeaux is frequently used but tends to burn the foliage and also discolors the plants, and for that reason cannot be used on blooming plants or those ready for the market.

NOTE.—Several of the photographs used in this circular were made by Mr. R. F. Poole. They are marked (R. F. P.).

OTHER CIRCULARS ON PLANT DISEASES

No.

- 35. Some Diseases of Nursery Stock.
- 51. Diseases of Grain and Forage Crops.
- 52. Common Diseases of the Pear.
- 53. Potato Diseases of New Jersey.
- 55. Common Diseases of the Grape.
- 68. Common Diseases of Cucumber and Melons.
- 71. Diseases of Tomatoes.
- 80. Common Diseases of the Apple, Pear and Quince.
- 81. Common Diseases of the Peach, Plum and Cherry.
- 84. Common Diseases of Beans and Peas.
- 88. Common Diseases of Berries.
- 89. Common Diseases of Garden Vegetables and Truck Crops.
- 95. Seed and Soil Treatment for the Control of Potato Scab.
- 96. Leaf Blight of the Tomato.

For the above circulars, write to the New Jersey Agricultural Experiment Station, New Brunswick, N. J.

